U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-288 731

Volatile Organic Compound Emission Inventory for Pulaski County, Arkansas

TRW Environmental Engineering Div, Vienna, VA

Prepared for

Environmental Protection Agency, Dallas, TX Air and Hazardous Materials Div

Oct 78

PB 288731

EPA-906/9-78-004
October 1978

VOLATILE ORGANIC COMPOUND EMISSION INVENTORY FOR PULASKI COUNTY, ARKANSAS

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 6
Air and Hazardous Materials Division
Dallas, Texas 75270

68

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA 906/9-78-004		PB288731

4. TITLE AND SUBTITLE	5. REPORT DATE
Volatile Organic Compound Emission Inventory for Pulaski County, Arkansas	October 1978
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
John Dadiani, Arthur B. Nunn, III, and Thomas J. Raubacher	TRW 68-02-2613-11-1
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
TRW Environmental Engineering Division 800 Follin Lane, S.E. Vienna, Virginia 22180	11. CONTRACT/GRANT NO. Contract No. 68-02-2613 Task No. 11
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
EPA Region 6 Air and Hazardous Materials Division 1201 Elm Street Dallas, Texas 75270	Final Report 14. SPONSORING AGENCY CODE 906/00

15. SUPPLEMENTARY NOTES
Supplements additional work for developing a control strategy to attain the national standard for photochemical oxidants in Pulaski County.

16. ABSTRACT
This project includes the development of a volatile organic compound emission inventory for Pulaski County, Arkansas which includes the Little Rock metropolitan area. The inventory was compiled in accordance with the methodology described in Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds (EPA-450/2-77-028). The inventory consists of emissions from stationary point sources, stationary area sources, and mobile sources. Emissions from mobile sources account for approximately 66 percent of total emissions. Stationary point source emissions account for only about 7 percent of the total, and point source emissions from adjacent counties do not appear to make a significant contribution. The volatile organic compound emission inventory represents calendar year 1977.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Arkansas Emissions Hydrocarbons Point sources Mobile emission sources	Pulaski County Emission Inventories Volatile organic compounds Vehicles	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited.	None	68
	20. SECURITY CLASS *(This page)*	22. PRICE
	None	PC A04 / MF A01

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

VOLATILE ORGANIC COMPOUND EMISSION INVENTORY

FOR PULASKI COUNTY, ARKANSAS

by

John Dadiani
Arthur B. Nunn, III
Thomas J. Raubacher

TRW Environmental Engineering Division
800 Follin Lane, S.E., Vienna, Virginia 22180

Contract No. 68-02-2613
Task No. 11

Anita B. Turpin, Project Officer
Air Program Branch
U. S. Environmental Protection Agency, Region 6
1201 Elm Street, Dallas, Texas 75270

October 1978

This report was furnished to the Environmental Protection Agency by the TRW Environmental Engineering Division, Vienna, Virginia 22180, in fulfillment of EPA Contract No. 68-02-2613, Task No. 11. This report has been reviewed by the Air Program Branch, Region 6, EPA and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGEMENT

This study was performed for the Air Program Branch, Region 6 Office of the U. S. Environmental Protection Agency. The technical direction and assistance of Ms. Anita Turpin and Mr. Robert Clark of the Air Program Branch in the execution of the task is gratefully acknowledged. The successful completion of the study is due in large part to the excellent cooperation extended by the staff of Mr. John Mitchell of the Air Division of the Arkansas Department of Pollution Control and Ecology. Special thanks go to Mr. Mac Faulkner, Mr. Wilson Tolefree, and Mr. Cecil Harrell for their assistance during this study.

CONTENTS

Acknowledgement iii

1. Introduction 1- 1
2. Summary and Results 2- 1
   References for Section 2 . . . . . 2- 5
3. Background for Emission Inventory 3- 1
   3.1 Clean Air Act 3- 1
   3.2 Definition of Study Area 3- 2
   References for Section 3 . . . . . 3- 3
4. Methodology 4- 1
   4.1 General Approach to Study 4- 1
   4.2 Stationary and Mobile Source Emissions 4- 3
      4.2.1 Stationary Point Source Emissions 4- 3
      4.2.2 Stationary Area Source Emissions 4- 6
      4.2.3 Mobile Source Emissions 4-20
   References for Section 4 4-40

Appendices

A. Stationary Point Source Emissions . . . . . A- 1
B. Stationary Area Source Emissions . . . . . B- 1
C. Mobile Source Emissions . . . . . C- 1

Preceding page blank

SECTION 1

INTRODUCTION

An emission inventory of volatile organic compounds (VOC) has been compiled for Pulaski County, Arkansas. This county is located in an area which is presently not attaining the National Ambient Air Quality Standard for photochemical oxidants. Under the requirements of the 1977 Clean Air Act Amendments a revised State Implementation Plan (SIP) is required for non-attainment areas, and must contain a current emission inventory. The SIP must be submitted to the Environmental Protection Agency no later than January 1, 1979 and be approved by July 1, 1979. This emission inventory has included sources in each of the three following major categories: stationary point sources, stationary area sources, and mobile sources. The compilation of the inventory has been in accordance with EPA approved procedures.

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 2

SUMMARY AND RESULTS

This emission inventory was compiled by the Environmental Engineering Division of TRW, Inc., for the Air Program Branch of the U. S. Environmental Protection Agency's Region 6 Office. The purpose of this inventory is to provide the State of Arkansas with the necessary information on volatile organic compound (VOC) emissions to develop and implement and effective control strategy for photochemical oxidants in Pulaski County. Under the requirements of the 1977 Clean Air Act Amendments, a revised State Implementation Plan (SIP) is required for those portions of the state not attaining National Ambient Air Quality Standards. As part of the revised SIP a current emission inventory is required.

This inventory was compiled in accordance with the methodology described in Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds.[1] The three major categories for which emissions were compiled are stationary point sources, stationary area sources, and mobile sources. The total emissions from these sources for Pulaski County is presented in Table 2-1. A more detailed compilation of emissions from each subcategory of emission sources is presented in Table 2-2. The significant results which emerge from these tables are as follows:

1. Of the three major categories of emission sources, mobile sources account for the highest amount of emissions in Pulaski County, contributing approximately 64 percent of the total. Stationary point sources contribute the least amount of emissions, only 7 percent of the total.

2. Bulk gasoline terminals are the major point sources in Pulaski County, contributing over 40

TABLE 2-1. SUMMARY OF 1977 VOC EMISSIONS (TONS/YEAR) FOR PULASKI COUNTY[a]

STATIONARY POINT SOURCE EMISSIONS	STATIONARY AREA SOURCE EMISSIONS	MOBILE SOURCE EMISSIONS	TOTAL
1,903.5 (7)	8,597.4 (29)	18,682.7 (64)	29,183.6

[a]The number in parentheses signifies the percentage that each source category contributes to the total county VOC emissions.

TABLE 2-2. PULASKI COUNTY VOC EMISSIONS FOR 1977

STATIONARY SOURCES		VOC EMISSIONS (TONS/YEAR)			
		STATIONARY POINT SOURCE EMISSIONS	STATIONARY AREA SOURCE EMISSIONS	MOBILE SOURCE EMISSIONS	TOTAL BASE YEAR EMISSIONS 1977
PETROLEUM REFINERIES	REFINERY FUGITIVES (LEAKS)				
	MISCELLANEOUS SOURCES A. PROCESS DRAINS AND WASTE B. VACUUM PRODUCING SYSTEMS C. PROCESS UNIT BLOWDOWN				
	OTHER				
STORAGE, TRANSPORTATION & MARKETING OF PETROLEUM PRODUCTS	OIL & GAS PRODUCTION FIELDS				
	NATURAL GAS AND NATURAL GASOLINE PROCESSING PLANTS				
	GASOLINE & CRUDE OIL STORAGE[1]				
	SHIP AND BARGE TRANSFER OF GASOLINE, CRUDE OIL, AND CHEMICALS		0.2		0.2
	BULK GASOLINE TERMINALS[2]	829.0			829.0
	GASOLINE BULK PLANTS[3]	120.7			120.7
	SERVICE STATION LOADING		987.1		987.1
	SERVICE STATION UNLOADING		766.0		766.0
	AVIATION GASOLINE HANDLING		110.8		110.8
INDUSTRIAL PROCESSES	ORGANIC CHEMICAL MANUFACTURE				
	PAINT MANUFACTURE	7.0			7.0
	VEGETABLE OIL PROCESSING	151.2			151.2
	PHARMACEUTICAL MANUFACTURE				
	PLASTIC PRODUCTS MANUFACTURE	335.6			335.6
	RUBBER PRODUCTS MANUFACTURE	62.8			62.8
	TEXTILE POLYMERS MANUFACTURE	43.6			43.6
	OTHERS	1.9			1.9
INDUSTRIAL SURFACE COATING	LARGE APPLIANCES		5.7		5.7
	MAGNET WIRE		182.4		182.4
	AUTOMOBILES		41.2		41.2
	CANS		14.1		14.1
	METAL COILS				
	PAPER	22.4	358.0		380.4
	FABRIC		163.7		163.7
	METAL FURNITURE				
	WOOD FURNITURE	144.0	44.1		188.1
	FLAT WOOD PRODUCTS	1.2	51.1		52.3
	OTHER METAL PRODUCTS	135.6	200.0		335.6
	OTHERS	1.2	352.8		354.0
[illegible] INDUSTRIAL SURFACE COATINGS	ARCHITECTURAL COATINGS		113.0		113.0
	AUTO REFINISHING	7.4	90.7		98.1
	OTHERS				
OTHER SOLVENT USE	DEGREASING	5.7	182.1		187.8
	DRY CLEANING		152.2		152.2
	GRAPHIC ARTS	34.2	950.6		984.8
	ADHESIVES				
	CUTBACK ASPHALT		0.0		0.0
	OTHER SOLVENT USE		3,726.5		3,726.5
OTHER MISCELLANEOUS	FUEL COMBUSTION				
	SOLID WASTE DISPOSAL				
	FOREST, AGRICULTURAL, AND OTHER OPEN BURNING		105.1		105.1
TOTAL VOC EMISSIONS FROM STATIONARY SOURCES		1,903.5	8,597.4		10,500.9
MOBILE SOURCES	HIGHWAY VEHICLES			16,657.3	16,657.3
	OFF-HIGHWAY VEHICLES			195.5	195.5
	RAIL			74.0	74.0
	AIRCRAFT			749.0	749.0
	VESSELS AND PLEASURE CRAFT			1,006.9	1,006.9
TOTAL VOC EMISSIONS FROM MOBILE SOURCES				18,682.7	
TOTAL VOLATILE ORGANIC COMPOUND EMISSIONS		1,903.5	8,597.4	18,682.7	29,183.6

[1] INCLUDES ALL STORAGE FACILITIES EXCEPT THOSE AT SERVICE STATIONS AND BULK PLANTS.
[2] EMISSIONS FROM LOADING TANK TRUCKS AND RAIL CARS.
[3] EMISSIONS FROM STORAGE AND TRANSFER OPERATIONS.

percent of the stationary point source emissions. There are several of these terminals located within the county, and the emissions from each of these are listed in Table A-1 in the appendix. There are a total of 27 sources in Pulaski County which emit more than one ton per year of volatile organic compounds. Emissions for these sources were calculated from information provided by the sources in a survey questionnaire. Since not all sources responded to the survey, the number of point sources may not necessarily be representative of Pulaski County.

3. Point sources in adjacent counties do not appear to be a major contributor to point source emissions in Pulaski County. Only Jefferson County was found to have any significant point sources, and of these, one has emissions greater than 100 tons per year. The sources in Jefferson County contribute a total of 256.7 tons per year, and are listed in Table A-2.

SECTION 2

REFERENCES

1. Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, Volume 1, EPA-450/2-77-028, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December, 1977.

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 3

BACKGROUND FOR EMISSION INVENTORY

3.1 CLEAN AIR ACT

Under the mandate of the 1970 Clean Air Act, the U. S. Environmental Protection Agency (EPA) promulgated primary and secondary National Ambient Air Quality Standards (NAAQS) for six criteria air pollutants.[1] Each state and territory was then required to submit to the Administrator of the EPA a plan for implementation, maintenance and enforcement of the air quality standards in each air quality control region (AQCR) within the state. Also included in the plans were attainment dates for the air quality standards in each AQCR. In those states that did not meet their attainment date, a revised State Implementation Plan (SIP) was required which demonstrated attainment of the standards. The Clean Air Act Amendments of 1977 retained the fundamental approach to air pollution control and also retained the State Implementation Plan as the mechanism for implementing this approach. Under the 1977 amendments, each state is required to submit to the EPA Administrator a list of air quality control regions which have attained standards, those which have not attained standards, and those for which there are insufficient data for classification.

For the air quality control regions not attaining the standards, the respective states must submit a revised SIP by January 1, 1979, which demonstrates attainment of the standards as expeditiously as practicable, but not later than December 31, 1982. For photochemical oxidants and carbon monoxide, an extension to 1987 is available if the state demonstrates that attainment by 1982 is not possible with reasonably available control measures. In the State of Arkansas, Pulaski County has been declared a non-attainment area for photochemical oxidants, based on an air quality monitoring project conducted during a three month period in the summer of 1977. A revised SIP

will, therefore, be required for Pulaski County. The 1977 Amendments specify that the revised SIP include a comprehensive, accurate, current inventory of actual emissions from all sources. To satisfy this requirement, an inventory of volatile organic compound (VOC) emissions has been compiled for Pulaski County. Since volatile organic compounds are precursors to the formation of photochemical oxidants in the atmosphere, the sources of VOC emissions must be determined before an effective control strategy can be developed and implemented.

3.2 DEFINITION OF STUDY AREA

Pulaski County is located in the Central Arkansas Intrastate air quality control region and is also a part of the Little Rock/North Little Rock Standard Metropolitan Statistical Area (S.M.S.A.). The county has a 1977 estimated population of 330,000 persons of which approximately 240,000 are located in the cities of Little Rock and North Little Rock.[2] Industrial activity in Pulaski County includes steel production, metal fabrication, furniture making, textile production, and a wide range of other manufacturing processes.

SECTION 3

REFERENCES

1. Clean Air Act, 42 U.S.C. 7401 et. seq., as amended by the Air Quality Act of 1967; Clean Air Amendments of 1970, PL 91-604; Clean Air Act Amendments of 1977, PL 95-95, August 7, 1977.

2. The Metropolitan Economy, Metropolitan Chamber of Commerce, Little Rock and North Little Rock, 1978.

THIS PAGE INTENTIONALLY LEFT BLANK

SECTION 4

METHODOLOGY

This section describes the general approach and methodology that was utilized in compiling the volatile organic compound emission inventory for Pulaski County, Arkansas. The specific techniques and assumptions used in determining the emissions are presented for each category of emission sources.

4.1 GENERAL APPROACH TO STUDY

The data presented in this document are the result of utilizing several techniques for collecting and analyzing information dealing with the operation of sources that are known and potential emitters of volatile organic compounds. The procedures followed in preparing this inventory are based on a recent EPA publication, Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds.[1] In a few cases it was found that the procedures recommended in this document were either not applicable to a particular source category, or that the information needed to compile the emissions was unavailable. In these cases, either a modified or revised procedure was utilized which is described in the following sections which discuss each of the emission source categories. The baseline year for the emissions presented in this document is 1977.

In determining which compounds to exempt from the emission inventory, the EPA recommended policy on control of volatile organic compounds described in the Federal Register of July 8, 1977, was followed.[2] The compounds listed in Table 4-1 were not included in the inventory, since they are exempt from future regulation as stated by the EPA policy. The compounds listed in Table 4-2 are of low photochemical reactivity, but do contribute to oxidant formation during periods of multiday stagnations and were, therefore, included in the inventory.

TABLE 4-1. VOLATILE ORGANIC COMPOUNDS EXEMPT FROM REGULATION UNDER STATE IMPLEMENTATION PLANS

METHANE
ETHANE
1, 1, 1 - TRICHLOROETHANE (METHYL CHLOROFORM)
TRICHLOROTRIFLUOROETHANE (FREON 113)

TABLE 4-2. VOLATILE ORGANIC COMPOUNDS OF LOW REACTIVITY

PROPANE	TERTIARY ALKYL ALCOHOLS
ACETONE	METHYL ACETATE
METHYL ETHYL KETONE	PHENYL ACETATE
METHANOL	ETHYL AMINES
ISOPROPANOL	ACETYLENE
METHYL BENZOATE	N, N - DIMETHYL FORMAMIDE

The emission calculations presented in this inventory are based on emission factors found in the most recent issue of AP-42, Compilation of Air Pollution Emission Factors.[3] In a few cases, emission factors were not available in this document, therefore, other sources were used which are described in the following sections. A specific example is the Mobile Source Emission Model developed by EPA, which was used to obtain the emission factors for highway vehicles.[4]

The emission factors presented in AP-42 are for the most part for total hydrocarbons, rather than for volatile organic hydrocarbons. In order to determine the reactive fraction of the total hydrocarbon emission, a reactivity factor was utilized. The reactivity factors for motor vehicles were obtained from the EPA Model, while for most of the remaining sources a recent TRW study sponsored by EPA was utilized.[5] The Monitoring and Data Analysis Division of the EPA Office of Air Quality Planning and Standards was contacted to determine if hydrocarbon reactivity factors for stationary sources were available, and since none were, this report was utilized. The reactivity factors vary for each source category as explained in the following sections

which describe the specific methodology utilized in compiling the emission inventory.

4.2 STATIONARY AND MOBILE SOURCE EMISSIONS

4.2.1 Stationary Point Source Emissions

Volatile organic compound emissions have been compiled for both stationary point and area sources. Point sources are usually defined as having a specified level of emissions such as 100 tons per year or greater. In addition, these sources usually have individual records of plant operations, including emissions data which are part of an operating permit system.

At the start of this inventory, there was no existing inventory of hydrocarbon emission sources in Pulaski County. A listing of potential sources in Pulaski County as well as some in the surrounding counties was developed by the State of Arkansas Department of Pollution Control and Ecology. A total of 249 sources comprised this list and each was mailed a questionnaire requesting data on the type and quantity of hydrocarbon material used, type of emission control equipment and efficiency, stack parameters where available, storage tank specifications, and an estimate of hydrocarbon emissions. In most cases, the emissions estimate did not appear on the questionnaire, therefore, they were calculated for all volatile organic compounds with the exception of those previously listed in Table 4-1. The emission factors used for the calculations for all sources were obtained from AP-42.

In calculating emissions from point sources, a basic assumption was made regarding the reactivity of hydrocarbon emissions. Emissions from all fuel combustion sources such as industrial and power plant boilers were assumed to be all methane on the basis of a previous TRW report and since AP-42 lists a negligible amount of hydrocarbon emissions for fuel combustion.[6] The majority of the emission calculations that were made were for petroleum product handling and storage and also for surface coating. An example of the methodology used for determining petroleum product handling emissions is as follows:

Example 1 - Calculation of breathing losses from a fixed roof storage tank.

The following general equation is used for this calculation:

$$L_B = 2.21 \times 10^{-4} M \left[\frac{P}{14.7-P}\right]^{0.68} D^{1.73} H^{0.51} \Delta T^{0.50} F_p C K_c$$

where:

L_B = Fixed roof breathing loss (lb/day)

M = Molecular weight of vapor in storage tank (lb/lb mole)

P = True vapor pressure at bulk liquid conditions (psia)

D = Tank diameter (ft)

H = Average vapor space height, including roof volume correction (ft); see note (1)

ΔT = Average ambient temperature change from day to night (°F)

F_p = Paint factor (dimensionless)

C = Adjustment factor for small diameter tanks (dimensionless)

K_c = Crude oil factor (dimensionless); see note (2)

Note: (1) The vapor space in a cone roof is equivalent in volume to a cylinder which has the same base diameter as the cone and is one-third the height of the cone.

(2) K_c = (0.65) for crude oil, K_c = (1.0) for gasoline and all other liquids.

Assume the following hypothetical design basis for a storage tank:

Tank capacity - 100,000 bbl.
Tank diameter - 125 ft.
Tank height - 46 ft.
Average diurnal temperature change - 23.3°F
Gasoline RVP - 9 psia
Gasoline temperature - 70°F

Specular aluminum painted tank
Roof slope is 0.1 ft/ft.

Substituting in the fixed roof tank breathing loss equation the following values:

where:

M = Molecular weight of gasoline vapors = 66.

P = True vapor of gasoline = 5.6 psia.

D = Tank diameter = 125 ft.

ΔT = Average diurnal temperature change = 23.3°F[7]

F_p = Paint factor = 1.20

C = Tank diameter adjustment factor = 1.0

K_c = Crude oil factor = 1.0

H = Average vapor space height. For a tank which is filled completely and emptied, the average liquid level is 1/2 the tank rim height, or 23 ft. The effective cone height is 1/3 of the cone height. The roof slope is 0.1 ft/ft and the tank radius is 62.5 ft. Effective cone height = (62.5 ft) (0.1 ft/ft) (1/3) = 2.08 ft.

H = Average vapor space height = 23 ft + 2 ft = 25 ft.

Therefore:

$$L_B = 2.21 \times 10^{-4} (66) \left[\frac{5.6}{14.7 - 5.6}\right]^{0.68} (125)^{1.73} (25)^{0.51} (23.3)^{0.50}$$
$$(1.2) (1.0) (1.0)$$

L_B = 1,328 lb/day or 242 tons/year.

Example 2 - Calculation of emissions from gasoline loading at bulk terminals.

Given the following parameters:

Annual throughput of gasoline - 15,000,000 gallons

Type of loading - submerged fill

Emission factor - 5 lb/10^3 gal transferred

VOC emissions (tons/year) = 15,000 x 5 ÷ 2000#/ton = 37.5

4.2.2 Stationary Area Source Emissions

Those sources which are either too small or too numerous to be inventoried on an individual basis are termed "area sources," and their emissions are aggregated for the total source category. A total of eleven categories of area sources have been included in this emission inventory and are described in the following subsections. Excluded from this inventory are emissions from commercial and residential space heating for the reasons discussed earlier regarding fuel combustion.

4.2.2.1 Service Station Gasoline Handling

Service station gasoline handling emissions involve losses incurred during the filling of underground storage tanks, underground tank breathing, and filling of automobile tanks. Emission estimates for all facets are based upon the amount of gasoline handled during 1977 in Pulaski County. State total gasoline sales data were obtained from the Arkansas Department of Revenue. This figure was then apportioned to Pulaski County on the basis of vehicle miles traveled (VMT).[8] The emission factors utilized are as follows:

Filling Underground Tanks - 11.5 lb/10^3 gal.

Underground Tank Breathing - 1.0 lb/10^3 gal.

Vehicle Refueling - 9.0 lb/10^3 gal.

Spillage - 0.7 lb/10^3 gal.

The emission factor for the filling of underground tanks is based on splash filling. Hydrocarbon emissions from service station gasoline handling are assumed to be 100% photochemically reactive.

Gasoline sales were apportioned to Pulaski County as follows:

Sales (gal) = (5,400.2 x 10^3/42,294.5 x 10^3) (1,236,936.3 x 10^3) =

157,933.6 x 10^3 gal

where:

$5{,}400.2 \times 10^3$ = 1977 Pulaski County VMT

$42{,}294.5 \times 10^3$ = 1977 Arkansas VMT

$1{,}236{,}933.6 \times 10^3$ = 1977 Arkansas Gasoline Sales (gal)

VOC emissions were calculated for Pulaski county as shown below:

VOC Emissions (tons/year) = A + B + C + D = 1,753.1

where:

A = Emissions from Filling Underground Tanks (tons/year) =
(11.5 lb/10^3 gal)(157,933.6214 x 10^3 gal)/(2000 lb/ton) =
908.1 tons/year

B = Emissions from Underground Tank Breathing (tons/year) =
(1.0 lb/10^3 gal)(157,933.6214 x 10^3 gal)/(2000 lb/ton) =
79.0 tons/year

C = Emissions from Vehicle Refueling (tons/year) =
(9.0 lb/10^3 gal)(157,933.6214 x 10^3 gal)/(2000 lb/ton) =
710.7 tons/year

D = Emissions from Gasoline Spillage (tons/year) =
(0.7 lb/10^3 gal)(157,933.6214 x 10^3 gal)/(2000 lb/ton) =
55.3

4.2.2.2 Aviation Fuel Handling

Aviation fuel handling was divided into the three major categories of military, commercial, and non-commercial airports. For Adams Field and Little Rock Air Force Base, actual fuel use data were obtained by personal contact with airport personnel. Aviation gasoline and jet naptha (JP-4) were the only fuels for which emissions were calculated in view of the fact that jet kerosene emissions were considered to be negligible, based on preliminary calculations. Aviation gasoline is the only fuel for which aircraft refueling emissions were calculated because JP-4 refueling is done in a closed system.

The emission factor used is the same as that for refueling automobiles. The emission factors used for aviation fuel handling are shown below:

On Field Storage of JP-4 - 2.5 lb/10^3 gal

On Field Storage of Gasoline - 10.0 lb/10^3 gal

Aircraft Refueling - 9.7 lb/10^3 gal

Filling Underground Tanks - 11.5 lb/10^3 gal

Underground Tank Breathing - 1.0 lb/10^3 gal

Little Rock Air Force Base reported consumption of 46,200,000 gal of JP-4 and 1,008,000 gal of aviation gasoline during 1977. Emissions were then calculated as follows:

$$\text{VOC Emissions (tons/year)} = J + G = 67.7$$

where:

J = JP-4 Storage Emissions (tons/year) =

$(46{,}200 \times 10^3 \text{ gal})(2.5 \text{ lb}/10^3 \text{ gal})/(2000 \text{ lb/ton}) =$
57.8 tons/year

G = Aviation Gasoline Storage and Aircraft Refueling Emissions

(tons/year) = $(1{,}008 \times 10^3 \text{ gal})\left((10.0 \text{ lb}/10^3 \text{ gal}) + (9.7 \text{ lb}/10^3 \text{ gal})\right)/(2000 \text{ lb/ton}) = 9.9$ tons/year

Adams field reported consumption of 8,592,452 gal. of aviation gasoline during 1977. There are no bulk storage facilities on the field, therefore, emissions were calculated for aircraft refueling only. The calculation is as follows:

$$\text{VOC Emissions (tons/year)} = (8{,}592.452 \times 10^3 \text{ gal}) \times (9.7 \text{ lb}/10^3 \text{ gal})/(2000 \text{ lb/ton}) = 41.7$$

State total non-commercial airport aviation gasoline consumption for 1975 was obtained from Highway Statistics.[9] A growth factor was applied to this to bring the total to the 1977 level.[10] This was calculated as follows:

1977 Aviation Gasoline Consumption = $(8{,}408{,}000 \text{ gal})(1.057)^2$ =

9,393,830 gal

This total figure was apportioned to Pulaski County on the basis of Landing and Take Off (LTO) cycles. State total data for 1975 were derived from Census of U. S. Civil Aircraft[11] and multiplied by the growth factor to obtain a 1977 estimate. Landing and Take Offs for 1974 at North Little Rock Municipal Airport were obtained from the Arkansas Department of Pollution Control and Ecology. This figure was also multiplied by the growth factor to yield a 1977 value. State aviation gasoline consumption was then apportioned to this airport as follows:

Aviation Gasoline Consumption (gal) = (10,776/849,439)(9,393,830) =

119,170

VOC emissions from non-commercial Aviation Gasoline handling were then calculated as shown below:

VOC Emissions (tons/year) = A + B + C = 1.4

where:

A = Emissions from Underground Tank Filling (tons/year) =

$(11.5 \text{ lb}/10^3 \text{ gal})(119.17 \times 10^3 \text{ gal})/(2000 \text{ lb/ton})$ =

0.7 tons/year

B = Emissions from Underground Tank Breathing (tons/year) =

$(1.0 \text{ lb}/10^3 \text{ gal})(119.17 \times 10^3 \text{ gal}) / (2000 \text{ lb/ton})$ =

0.1 tons/year

C = Emissions from Aircraft Refueling, Including Spillage (tons/year) =

$(9.7 \text{ lb}/10^3 \text{ gal})(119.17 \times 10^3 \text{ gal})/(2000 \text{ lb/ton})$ = 0.6 tons/year

The total VOC emissions from aviation fuel consumption are equal to the sum of those emissions from Little Rock Air Force Base, Adams Field, and North Little Rock Municipal Airport. This total value is 110.8 tons/year which is considered to be 100% photochemically reactive.

4.2.2.3 Barge Loading

Barge loading emissions were calculated for the petroleum products handled at the Port of Little Rock. The tonnage of petroleum products handled during 1977 were obtained from the Little Rock Port Authority. This was a total figure for all petroleum products, therefore, it was necessary to separate it into it's constituents. This was accomplished by assuming that the percentage of each constituent is the same for the Port of Little Rock as it is for the Little Rock U. S. Army Engineer District as published in Waterborne Commerce of the United States.[12] The percentages of each of the petroleum products are shown below:

Crude oil - 2.5%

Gasoline - 0.5%

Distillate Fuel Oil - 13.5%

Residual Fuel Oil _ 83.5%

The Little Rock Port Authority reported that 39,398 tons of petroleum products were handled during 1977. This was broken-down as follows:

Crude Oil = 39,398 x 0.025 = 985.0 tons

Gasoline = 39,398 x 0.005 = 197.0 tons

Distillate Fuel Oil = 39,398 x 0.135 = 5,318.7 tons

Residual Fuel Oil = 39,398 x 0.835 = 32,897.3 tons

Densities and emission factors of the four products were obtained from AP-42, and are shown below.

	DENSITY (tons/10^3 gal)	EMISSION FACTOR (lb/10^3 gal)
CRUDE OIL	3.55	1.7
GASOLINE	2.80	4.0
DISTILLATE FUEL OIL	3.55	0.012
RESIDUAL FUEL OIL	3.95	0.00009

Emissions are calculated using the following equations:

$$\text{VOC Emissions (tons/year)} = P \div D \times E_f \div 2000 \text{ lb/ton}$$

where:

P = tons of product handled

D = density of product

E_f = emission factor

VOC emissions from crude oil handling are:

$$(985.0 \text{ tons}/3.55 \text{ tons}/10^3 \text{ gal})(1.7 \text{ lb}/10^3 \text{ gal}/2000 \text{ lb ton}) =$$

$$0.2 \text{ tons/year}$$

The emissions from gasoline, distillate oil, and residual oil are 0.1, 0.0, and 0.0 tons/year, respectively; therefore, total VOC emission (tons/year = 0.3).

4.2.2.4 Dry Cleaning Emissions

Dry cleaning emission factors are usually based on the weight of clothes cleaned. Data pertaining to the amount of clothes cleaned per establishment, however, are extremely difficult to obtain and using this approach would not take into account varying levels of emission controls at the different establishments. It was decided, therefore, to calculate emissions on the basis of solvent consumption assuming that all solvent purchased for dry cleaning is eventually evaporated to the atmosphere.

The three types of solvents most commonly used for dry cleaning are perchloroethylene, stoddard, and Freon-113. Perchloroethylene is used primarily by commercial establishments. Industrial dry cleaners usually use stoddard and coin-operated dry cleaners most often use Freon-113.[13] Since Freon-113 is photochemically non-reactive, coin-operated dry cleaning establishments were not included in this inventory. The assumption was made that all commercial dry cleaners use perchloroethylene and all industrial dry cleaners use stoddard solvent.

Several solvent distributers in the Pulaski County area were contacted and an estimate of 18,720 gallons per year of perchloroethylene and 6,000 gal per year of stoddard consumption were obtained. Densities of

13.6 lb/gal for perchloroethylene and 8.3 lb/gal for stoddard solvent were obtained and emissions were calculated as follows:

$$\text{VOC Emissions (tons/year)} = P + S = 152.2$$

where:

P = Perchloroethylene Emissions (tons/year) =
(18,720 gal)(13.6 lb/gal)/(2000 lb/ton) = 127.3 tons/year

S = Stoddard Solvent Emissions (tons/year) =
(6,000 gal)(8.3 lb/gal)/(2000 lb/ton) = 24.9 tons/year.

4.2.2.5 Degreasing

Degreasing emissions were calculated on the basis of solvent consumption with the assumption that all solvent used in degreasing operations is eventually evaporated into the atmosphere. Perchloroethylene, trichloroethylene, 1, 1, 1-Trichloroethane, and methylene chloride are the four major solvents used in degreasing operations. Emissions from 1, 1, 1 - Trichloroethane are excluded from the inventory due to the fact that they are photochemically non-reactive.

The figure for 1975 national sales of degreasing solvents was obtained from Synthetic Organic Chemicals, United States Production and Sales, 1975.[14] Methodologies for Countywide Estimation of Coal, Gas, and Organic Solvent Consumption[15] estimates that 15% of all perchloroethylene, 87% of all trichloroethylene, and 11% of all methylene chloride consumption is used in degreasing operations. This solvent use figure was then apportioned to Pulaski County on the basis of employment in Standard Industrial Classification (SIC) codes 34 through 39. Pulaski County employment figures were obtained from Arkansas County Business Patterns, 1975.[16] United States employment figures were taken from the 1967 and 1972 Census of Selected Services[17] using historical growth rates as a basis for projection to 1975. After emissions based on 1975 solvent consumption were calculated, they were projected to 1977 on the basis of historical growth trends of employment in SIC codes 34 through 39 in the State of Arkansas. The emissions calculation is shown below:

$$\text{VOC Emissions (tons/year)} = (0.64)\left(\frac{11,077}{7,567,129}\right)(388,656,110 \text{ lb/year})/$$

$$(2000 \text{ lb/ton}) = 182.1$$

where:

0.64	= 1975 to 1977 Arkansas Growth Factor
11,077	= 1975 Pulaski County Employment in SIC Codes 34-39
7,567,129	= 1975 United States Employment in SIC Codes 34-39
388,656,110 lb/year	= 1975 United States Degreasing Solvent Consumption minus 1,1,1-Trichloroethane

All degreasing solvents are considered to be 100% photochemically reactive.

4.2.2.6 Surface Coating Emissions

Surface Coating emissions are the most complex of the area sources. There are a large number of different types of operations involved in surface coating and a large number of different solvents involved. Emissions were separated into the industrial and non-industrial categories recommended in the guideline document. These categories and their SIC codes are listed in Table 4-3. Listed in Table 4-4 are the eleven major solvents used in surface coating activities. Listed also are the percentage of the national consumption of each solvent which is used for surface coating.

TABLE 4-3. SURFACE COATING PROCESSES

SIC CODE	PROCESS
15	ARCHITECTURAL COATING
22,23	FABRIC
24	FLAT WOOD PRODUCTS
25	WOOD FURNITURE
26, 27	PAPER
3411	CANS

TABLE 4-3. (CONCLUDED)

SIC CODE	PROCESS
358	LARGE APPLIANCES
36	MAGNETIC WIRE
37	TRANSPORTATION EQUIPMENT
75	AUTO REFINISHING
34, 35	OTHER METAL PRODUCTS
31, 32, 38, 39	OTHERS

TABLE 4-4. SURFACE COATING SOLVENT USE

SOLVENT	% USED FOR SURFACE COATING
SPECIAL NAPTHAS	26.0%
ETHANOL	4.0%
TOLUENE	5.0%
ACETONE	9.0%
XYLENE	6.0%
METHYL ETHYL KETONE	65.0%
METHYLENE CHLORIDE	31.0%
ETHYLENE DICHLORIDE	0.3%
ETHYL ACETATE	70.0%
CYCLOHEXANE	2.0%
METHYL ISOBUTYL KETONE	65.0%

By applying the above percentage figures to national consumption data for the solvents, taken from references 14 and 18, a figure for national consumption of surface coating solvents is obtained. Solvent consumption is apportioned to Pulaski County on the basis of employment within the specific

SIC codes. National employment figures are based on the total of all SIC codes listed in Table 4-3. County employment is divided into the specific processes by way of the applicable SIC codes. This breakdown was carried out for each of the twelve processes.

It is assumed that all volatile solvents used in surface coating evaporate into the atmosphere; therefore, emissions are based directly on solvent consumption. As previously delineated, employment data were derived from references 16 and 17. Growth factors for 1975 to 1977 were calculated for each surface coating category separately.

Using surface coating of paper products as an example, the general equation used to calculate VOC emissions is as follows:

$$\text{VOC Emissions (tons/year)} = (1.02657)\left(\frac{3,444}{15,551,661}\right)$$

$$(3,156,065,900 \text{ lb/year}) \div (2000 \text{ lb/ton}) = 358.0$$

where:

1.02657	= Arkansas Growth Factor (1975 to 1977) for SIC Codes 26 and 27
3,444	= Pulaski County Employment in SIC Codes 26 & 27
15,551,661	= United States Employment in All Surface Coating SIC Codes
3,156,065,900 lb/year	= 1975 United States Consumption of Surface Coating Solvents

This calculation is repeated for each surface coating category. The only figures which vary are the county employment and growth factors for each surface coating SIC. All other figures remain constant. Emissions are considered to be 100% photochemically reactive.

A complete listing of surface coating emissions is found in Table B-1.

4.2.2.7 Printing and Publishing

Emissions from printing and publishing operations are due primarily to solvent usage for the cleaning of presses. Some volatile organics are present in ink, however, those vary greatly with different types of ink and their contribution to the overall emissions from printing and publishing are minimal. Emissions, therefore, are based on consumption of these cleaning solvents. Reference 15 estimates that 8% of all special naptha consumption, 5% of all toluene consumption, and 8% of all ethyl acetate consumption are used for printing and publishing operations. National consumption figures for these solvents were taken from references 14 and 18. Solvent consumption was apportioned to the county on the basis of employment in SIC codes 264, 265, and 27. As in previous methodologies, these data were taken from references 16 and 17.

The equation used to calculate VOC emissions from printing and publishing is shown below:

$$\text{VOC Emissions (tons/year)} = (1.02657)\left(\frac{3,575}{1,489,177}\right)$$

$$(771,469,040 \text{ lb/year}) \div (2000 \text{ lb/ton}) = 950.6$$

where:

1.02657	= 1975 to 1977 Arkansas Growth Factor
3,575	= Pulaski County Employment in SIC Codes 264, 265, and 27
1,489,177	= 1975 United States Employment in SIC Codes 264, 265, and 27
771,469,040 lb/year	= 1975 United States Printing and Publishing Solvent Consumption

All emissions are considered to be 100% photochemically reactive.

4.2.2.8 Other Solvent Use

A large amount of solvent is consumed each year by areas other than those described in the previous sections. These have been grouped into the classification of "other" solvent use. Table 4-5 lists the solvents that are

used in this category. Listed also is the percent of the total consumption of each solvent that is used in this area.

TABLE 4-5. "OTHER" SOLVENT USE

SOLVENT	% OF TOTAL CONSUMPTION USED IN "OTHER" CATEGORY
SPECIAL NAPTHAS	60.0%
PERCHLOROETHYLENE	10.0%
ETHANOL	35.0%
TRICHLOROETHYLENE	3.0%
ACETONE	16.0%
XYLENE	7.0%
METHYL ETHYL KETONE	7.0%
METHYLENE CHLORIDE	37.0%
METHANOL	9.0%
ETHYLENE DICHLORIDE	2.7%
METHYL ISOBUTYL KETONE	25.0%

Not included in this listing are Freon 113 and 1, 1, 1 - Trichloroethane because of their non-reactivity.

Solvent consumption is apportioned to the county level on the basis of population and employment in SIC codes 19-39. The apportioning percentage is the average of the percentages derived from these two variables. Employment figures were obtained from references 16 and 17. National population statistics were obtained from Current Population Reports as published by the Bureau of Census.[19] County level population statistics for Arkansas were obtained from the University of Arkansas.[20] Growth factors for the 1975 to 1977 period were based equally upon state population growth and employment growth in the applicable SIC codes.

The equation used to calculate VOC emissions from "other" solvent use is as follows:

$$\text{VOC Emissions (tons/year)} = (0.8789)\left(\frac{\frac{316,600}{212,748,000} + \frac{25,088}{18,108,419}}{2}\right)$$

$$(5,901,981,800) \div (2000 \text{ lb/ton}) = 3,726.5$$

where:

0.87890	= 1975 to 1977 Growth Rate
316,600	= Pulaski County Population
212,748,000	= 1975 United States Population
25,088	= 1975 Pulaski County Employment in SIC Codes 19-39
18,108,419	= 1975 United States Employment in SIC Codes 19-39
5,901,981,800 lb/year	= 1975 United States Solvent Consumption

Emissions are considered to be 100% photochemically reactive.

4.2.2.9 Cutback Asphalt Paving

The highway departments of the County of Pulaski, City of Little Rock, and City of North Little Rock were contacted for estimates of the amount of cutback asphalt used in their jurisdictions during 1977. All three agencies reported that none was used; therefore, no emissions are reported.

4.2.2.10 Forest Fires

Forest fire emissions are based on data provided by the Arkansas Forestry Commission pertaining to the acreage of forest land burned in Pulaski County during 1977. Using AP-42 fuel loading and emission factors, total hydrocarbon emissions were calculated. Of these emissions, 38% were considered to be photochemically reactive.[5]

VOC emissions were calculated as shown below:

$$\text{VOC Emissions (tons/year)} = (\text{THC})\ (0.38) = 80.6$$

where:

THC = Total Hydrocarbon Emissions (tons/year) =
(1,965 acres)(216 lb/acre)/(2000 lb/ton) = 212.2 tons/year

Note: 1,965 = Acres of Forest Land Burned in Pulaski County (1977)

216 = Emission Factor

0.38 = Reactivity Factor

4.2.2.11 Agricultural Burning

Agricultural burning emissions were calculated on the assumption that all rice fields are burned off once each year. The number of acres of rice grown in Pulaski County was obtained from Arkansas Counties Social and Economic Profile.[21]

Total hydrocarbon emissions were calculated using AP-42 fuel loading and emission factors. A reactivity factor of 0.38 was applied to yield VOC emissions.[5]

The equation used to calculate VOC emissions from agricultural burning is shown below:

VOC Emissions (tons/year) = (0.38)(4,290 acres)(3.0 tons/acre)
(10.0 lb/ton)/(2000 lb/ton) = 24.5

where:

4,290 = Number of Acres of Rice Crops in Pulaski County

3.0 tons/acre = Fuel Loading Factor

10.0 lb/ton = Emission Factor

4.2.2.12 Pesticide Application Emissions

Some commonly used pesticides are suspended in a solvent base for ease of application. This solvent evaporates upon application leaving the pesticide residue on the crops. Volatile organic emissions can be estimated using the quantity of these pesticides applied and percent of which is solvent. Several attempts were made to obtain these data; however, it was unavailable

from either state or Federal sources. These emissions, therefore, are omitted from this inventory.

4.2.3 Mobile Source Emissions

VOC emissions from mobile sources are categorized into the following areas:

- Highway motor vehicles
- Aircraft
- Vessels and pleasure craft
- Railroads
- Other off-high fuel use

The methodologies used in compiling the inventory for the above categories are discussed in the following subsections. Also, the calculations to obtain VOC emissions for Pulaski County are shown throughout. All pertinent data and results used and tabulated in the inventory for mobile sources can be found in Appendix C.

4.2.3.1 Highway Motor Vehicles

Highway motor vehicles were classified into the following categories:

- Light-duty automobiles (LDV)
- Light-duty trucks 1 (LDT1)
- Light-duty trucks 2 (LDT2)
- Heavy-duty gasoline powered vehicles (HDG)
- Heavy-duty diesel powered vehicles (HDD)
- Motorcycles (MC)

In the above classification, light-duty trucks 1 are those trucks weighing 6,000 lbs. (gross vehicle weight) and less, light-duty trucks 2 weigh between 6,001-8,500 lbs., and heavy duty vehicles weigh over 8,500 lbs.

In order to estimate VOC emissions from highway motor vehicles, vehicle miles of travel (VMT) data were collected, and emission factors

calculated for Pulaski County. Emissions were then calculated by multiplying the VMT data by the appropriate emission factor.

VMT data were collected by roadway type from the Arkansas State Highway and Transportation Department.[8] The roadways were classified according to the state highway system and are as follows:

- Interstate
- Federal Aid Primary
- Federal Aid Secondary
- Non-federal Aid System

These were further separated to distinguish between VMT in rural, municipal, and urban areas. This allows for greater sensitivity, since mobile source emission factors vary appreciably with speed. VMT from local roads, not included in the state highway system were also obtained from the Arkansas State Highway and Transportation Department. The local roads were classified as follows:

- County Federal Aid
- County Non-Federal Aid
- Forest highways, Federal Aid Secondary
- Forest development, Federal Aid Secondary
- Forest development, Non-federal Aid System
- Federal reservation
- City streets, Federal Aid Secondary, extensions
- City streets, Non-Federal Aid Secondary
- Other city streets

Emission Factors--Emission factors were calculated for the six highway motor vehicle classes (light-duty automobile, light-duty truck 1, light-duty truck 2, heavy-duty gas, heavy-duty diesel and motorcycle) for exhaust, evaporative and crankase hydrocarbon emissions by the Mobile Source Emissions Model.[4] This model follows the procedures outlined in the document

Mobile Source Emission Factors[22] (latest update to AP-42, including supplements 1-7, for calculating emission factors for highway motor vehicles).

The emission factors for each vehicle category were weighted according to the percent of the total VMT each contributed. Since the VMT mix for Arkansas highways was not available, the nationwide VMT mix was used;[4] LDV = 80.3%, LDT1 = 5.8%, LDT2 = 5.8%, HDG = 4.5%, HDD = 3.1%, and MC = 0.5%. Emission factors are dependent upon vehicle population by model year, average vehicle speed, ambient temperature, and percent cold/hot start operations. Input data into the mobile source emissions model will be discussed in the following paragraphs.

Light-duty automobile registration data by model year for Pulaski County were obtained from the Motor Statistical Division of the R. L. Polk Company.[23] Using the state highway system and local roadtype classifications, the average speeds assumed for calculation of emission factors were:*

	URBAN (mph)	RURAL (mph)
INTERSTATE	55.8	60.3
FEDERAL AID PRIMARY	45.0	57.8
FEDERAL AID SECONDARY	45.0	53.5
NON-FEDERAL AID	40.0	45.0
COUNTY FEDERAL AID	45.0	45.0
COUNTY NON-FEDERAL AID	40.0	40.0
FEDERAL RESERVATION	25.0	25.0
CITY STREETS, NON-FEDERAL AID SECONDARY	30.0	--
OTHER CITY STREETS	30.0	--

Temperature data for Pulaski county was obtained from the National Oceanic and Atmospheric Administration (NOAA).[7] The percent cold/hot start

*Based on data obtained from the Arkansas State Highway and Transportation Department.

operations used were 20.6, 27.3, and 20.6%; these represent the national averages. [4] An air conditioning correction factor (1.03) for light-duty vehicles (automobiles) was used, by assuming air conditioners in automobiles are in use 50% of the time for seven months of the year. The non-methane hydrocarbon emissions were computed using the reactivity factors in the Mobile Source Emissions Model. [4]

Therefore, a total of eight computer runs were made, corresponding to the eight different roadway speeds. These emission factors (Table C-1) were then multiplied by the corresponding VMT to obtain VOC emissions.

The general equation to calculate motor vehicle VOC emissions (tons/year) is:

$$\text{VOC Emissions} = E_f \times \text{VMT} \times 365 \text{ days/year} \div 907{,}180 \text{ grams/ton}$$

where:

E_f = Emission factor from Mobile Source Emissions Model (Table C-1)

VMT= Vehicle miles of travel (Table C-1)

Pulaski county VOC emissions (tons/year) from highway motor vehicles are:

1. For 25 mph average speed =
   9.38 x 167 x 365 ÷ 907,180 = 0.63
2. For 30 mph average speed =
   8.59 x 1,690,122 x 365 ÷ 907,180 = 5841.3
3. For 40 mph average speed =
   7.61 x 564,700 x 365 ÷ 907,180 = 1729.0
4. For 45 mph average speed =
   7.36 x 1,380,418 x 365 ÷ 907,180 = 4087.8
5. For 53.5 mph average speed =
   7.18 x 45,373 x 365 ÷ 907,180 = 131.1
6. For 55.8 mph average speed =
   7.09 x 1,200,971 x 365 ÷ 907,180 = 3425.9

7. For 57.8 mph average speed =
   7.00 x 246,041 x 365 ÷ 907,180 = 693.0

8. For 60.3 mph average speed =
   6.83 x 272,423 x 365 ÷ 907,180 = 748.6

TOTAL 16,657.3

VOC emissions (tons/year) from highway motor vehicles can be found in Table C-1.

4.2.3.2 Aircraft

Aircraft VOC emissions were based on the number of landing and takeoff (LTO) cycles performed by each type of aircraft. Aircraft were categorized into the following four general classes:

- Commercial air carrier
- General aviation
- Military
- Helicopter

These four classes were further subdivided by the type of power supply: (1) jet, (2) turboprop, or (3) piston. Since the emission factors in AP-42 were based on a per engine basis, the actual aircraft model or the number of engines on each aircraft that comprised a class were found. If different aircraft with varying numbers of engines made up a particular category, each was weighted by the number of LTO cycles.

There are three airports with active airstrips in Pulaski county. They are:

- Adams Field
- North Little Rock Municipal Airport
- Little Rock Air Force Base

Data for 1977 LTO cycles were obtained from Adams field by personal contact. The aircraft fleet mix for this airport as well as for North Little Rock Municipal Airport was obtained from a 1974 Emissions Inventory by the Arkansas Department of Pollution Control and Ecology.[24] The 1977 LTO cycles were

projected using annual growth factors from the FAA report Aviation Forecasts - Fiscal Years 1978-1989.[10] Aircraft operations for Little Rock AFB were obtained for the years 1973-1976 from the FAA report Military Air Traffic Activity Report.[25] The 1977 LTO cycles were obtained by projecting the 1977 operations from the 1973-1976 data and then by dividing the 1977 operations in half. The aircraft fleet mix was obtained from the Arkansas Department of Pollution Control and Ecology.

The emission and reactivity factors were taken from AP-42 and the Los Angeles Study, respectively.[5] The general equation used to calculate VOC emissions (tons/year) for each aircraft type is as follows:

$$\text{VOC Emissions (tons/year)} = \text{LTO} \times \text{NOE}_{(\text{engines})} \times E_f(\text{lbs/engine}) \times R \div 2000 \text{ lbs/ton}$$

where:

LTO = 1977 landing-takeoff cycles (Table C-2)

R = Reactivity factor from Los Angeles Study[5]

NOE = Number of engines

E_f = Emission factor from AP-42

For Pulaski County, VOC emissions (tons/year) are:

1. Medium Range Jet =
   9,262 x 2.5 x 4.9 x 0.93 ÷ 2,000 = 52.8
2. Air Carrier Turboprop =
   2,997 x 2 x 2.9 x 0.93 ÷ 2,000 = 8.1
3. Business Jet =
   1,260 x 2 x 3.6 x 0.93 ÷ 2,000 = 4.2
4. General Aviation (1 engine) =
   44,083 x 1 x 0.40 x 0.80 ÷ 2,000 = 7.1
   (2 engines) =
   29,811 x 2 x 0.40 x 0.80 ÷ 2,000 = 9.5

5. Military Jet =
70,674 x 4 x 5.075 x 0.93 ÷ 2,000 = 667.1

6. Helicopter (turbine) =
673 x 1 x 0.52 x 0.93 ÷ 2,000 = 0.2

TOTAL 749.0

VOC emissions from aircraft can be found in Table C-2.

4.2.3.3 Vessels and Pleasure Craft

Total VOC emissions from waterborne activity includes emissions from both vessels and pleasure craft, however, the methodologies used to calculate emissions from each are different and will be discussed separately in the following subsections.

4.2.3.3.1 Vessels

This category includes large cargo and passenger ships, oil tankers, tugboats and all other steamships and motorships that use fuel oil. Since there are no vessels that operate their engines while in port, only underway emissions were calculated.

VOC emissions were estimated according to the guideline document,[1] using vessel movement data from the U. S. Army Corps of Engineers, Waterborne Commerce of the United States[12] and fuel consumption data from the Department of Energy's, Energy Data Reports.[26] Average annual growth factors based upon historical growth in freight tonnage between 1963 and 1976 were used to project 1977 vessel VOC emissions.[12]

Underway VOC Emissions

Underway VOC emissions were calculated by estimating the amount of distillate* fuel oil burned underway, apportioning the fuel to the port of Little Rock and Pulaski county, and multiplying by the appropriate emission factor from AP-42.

Since there were no in port emissions, the state total for distillate oil consumption from the Energy Data Reports,[26] is the amount of fuel

*According to the procedures document,[1] underway emissions were based solely on diesel fuel consumption data.

consumed underway. This fuel oil use was distributed to the ports according to tonnage handled; it was then divided among the counties along the waterways by the amount of shoreline mileage.

The general equation used to calculate underway VOC emissions (tons/year) from vessels is:

VOC Emissions (tons/year) = FUEL (gals.) ÷ TM (miles) x 1.06 x M (miles) ÷ 1,000 x E_f (lbs/10^3 gals.) x R ÷ 2,000 lbs/ton

where:

FUEL = Total gallons of fuel apportioned to respective port

TM = Total miles of shoreline for all counties along waterway in respective port area

1.06 = Growth factor

M = Miles of shoreline for Pulaski County

E_f = Emission factor from AP-42 (50 lbs/10^3 gals)

R = Reactivity factor (0.15)[5]

1,000 = Converts fuel usage data to 1,000 gal. units

Underway VOC emissions (tons/year) for Pulaski County are:

VOC Emissions (tons/year) = 8,559,175 ÷ 336 x 1.06 x 52 ÷ 1,000 x 50 x 0.15 ÷ 2,000 = 5.3

Underway VOC emissions (tons/year) from vessels for Pulaski County can be found in Table C-3.

4.2.3.3.2 Pleasure Craft

Emissions from smaller vessels (pleasure and small commercial boats) were estimated from registration data for motorboats, obtained from the boat registration office of the Motor Vehicle Department, State Game and Fish Commission, and U. S. Coast Guard. Registration for Pulaski County for boats five tons and less were generated by the State Game and Fish Commission; boats that had a gross weight of greater than five tons were obtained from the U. S. Coast Guard by district. Registrations (for boats greater than

5 tons) for Pulaski county were found by checking owners addresses for boats registered in the Little Rock district.

All boats registered with the U. S. Coast Guard were assumed to operate on diesel fuel. All other inboard and outboard boats were distributed in the following manner:

(1) all inboards 28' and less and all outboards were assumed to use gasoline and*

(2) all inboards greater than 28' were assumed to use diesel fuel*

Emissions from diesel powered boats were calculated assuming the national average for annual usage and a fuel consumption rate of 10 gal/hr.** Also, the national averages for annual usage and fuel consumption were used in calculating VOC emissions from gasoline powered boats. All outboard engines were assumed to be 2-stroke; the reactivity factor for two-stroke motorcycles from Mobile Source Emission Factors[22] was used. The reactivity factors for diesel and gasoline automobile engines from the Los Angeles Study[5] were used for diesel and gasoline inboard engines, respectively.

The general equations for fuel usage are given below:

Inboard gasoline consumption = Number of registered inboards x 3 gals/hr x 10 hrs/mo x C (mo/yr)

Inboard gasoline consumption = Number of registered inboards x 10 gals/hr x 10 hrs/mo x C (mo/yr)

Outboard gasoline consumption = Number of registered outboards x 1.5 gals/hr x 10 hrs/mo x C (mo/yr)

*This information was obtained from personal contact with local marinas and from the staff of the Boating Industry Magazine.

**Obtained from personal contact with local marinas.

where:

C = Number of months during which the monthly mean temperature exceeds 55°F for counties south of 37° latitude

Fuel consumption (gals/year) for Pulaski county is:

1. Inboard gasoline consumption =
   368 x 3 x 10 x 8 = 88,320
2. Inboard diesel consumption =
   89 x 10 x 10 x 8 = 71,200
3. Outboard gasoline consumption =
   15,191 x 1.5 x 10 x 8 = 1,822,920

The general equation used to calculate VOC emissions (tons/year) from pleasure craft is:

$$\text{VOC Emissions (tons/year)} = \text{FUEL (gals/year)} \div 1{,}000 \times E_f \text{ (lbs/}10^3\text{ gals)} \times R \div 2{,}000 \text{ lbs/ton}$$

where:

FUEL = Fuel used by each engine and fuel type in gals/year

1,000 = Converts fuel usage to 1,000 gallon units

R = Reactivity factor[5,22]

E_f = Emission factor by engine and fuel type from AP-42[3]

VOC emissions (tons/year) for Pulaski county from pleasure and small commercial boats are:

1. Inboard (gasoline) =
   88,320 ÷ 1,000 x 86 x 0.86 ÷ 2,000 = 3.3
2. Inboard (diesel) =
   71,200 ÷ 1,000 x 180 x 0.89 ÷ 2,000 = 5.7
3. Outboard (gasoline) =
   1,822,920 ÷ 1,000 x 1,100 x 0.99 ÷ 2,000 = 992.6

TOTAL 1,001.6

VOC emissions from pleasure craft can be found in Table C-3.

4.2.3.4 Railroads

Railroad activities are classified into two general areas: (1) road haul service and (2) railyard switching. VOC emissions are estimated based on the amount of fuel oil used by locomotives, which is multiplied by the appropriate emission factor from AP-42. Locomotive engines were assumed to have the following mix:

Road-Haul Service

- 2-stroke supercharged (47%)
- 2-stroke turbocharged (47%)
- 4-stroke turbocharged (6%)

Railyard Switching

- 2-stroke supercharged (100%)

Statewide fuel consumption data and type of locomotive engine mix were obtained from the 1977 annual reports and personal contact with railroad companies operating in Arkansas.[27] These statewide totals (for each rail company) were then apportioned to the inventory areas by the amount of rail mileage each company operated in Pulaski County. This assumes that all miles of rail for each company were travelled over equally. The miles of rail for each company by county were estimated or measured from a railroad transportation map of Arkansas.[28]

The general equation to calculate VOC emissions (tons/year) from locomotives is:

$$\text{VOC Emissions (tons/year)} = FC \times M \div 1{,}000 \times E_f \times R \div 2{,}000 \text{ lbs/ton}$$

where:

FC = Fuel oil consumption (gals/year) for road haul service and or railyard switching

M = Percent (in fraction form) of total population each engine category contributed

1,000 = Converts fuel usage data to 1,000 gal units

E_f = Emission factor from AP-42 in lbs/1,000 gal.

R = Reactivity factor (used reactivity factor for motor vehicle diesel engines, 0.89)[5]

VOC emissions (tons/year) from locomotives for Pulaski county are:

Road Haul Service

1. 4-stroke turbocharged =
   1,848,576 gals/year x 0.06 ÷ 1,000 x
   99 lbs/10^3 gals x 0.89 ÷ 2,000 lbs/ton = 4.9
2. 2-stroke supercharged =
   1,848,576 gals/yr x 0.47 ÷ 1,000 x
   148 lbs/10^3 gals x 0.89 ÷ 2,000 lbs/ton = 57.2
3. 2-stroke turbocharged =
   1,848,576 gals/year x 0.47 ÷ 1,000 x
   28 lbs/10^3 gals x 0.89 ÷ 2,000 lbs/ton = 10.8

Railyard - Switching

1. 2-stroke supercharged =
   12,680 gals/year x 1.00 ÷ 1,000 x
   190 lbs/10^3 gals x 0.89 ÷ 2,000 lbs/ton = 1.1

TOTAL 74.0

4.2.3.5 Other Off-Highway Fuel Use

Other off-highway fuel user's are classified into the following categories:

- Farm equipment
- Construction equipment
- Industrial equipment
- Lawn and garden equipment

The methodologies used for each of these are discussed in the following sub-sections.

4.2.3.5.1 Farm Equipment

Farm equipment was subdivided into the five following areas:

- Combines
- Balers
- Harvesters
- Tractors
- General purpose

VOC emissions were based on the population of equipment in each of the above categories for Pulaski County. This information was obtained from the Census of Agriculture for the years 1969 and 1974.[29] Population figures for 1977 were estimated by growth factors, which were based on historical growth trends. National figures, which were available in the guideline document[1] were used for:

1. the percentages of each type of equipment that were either gasoline or diesel powered,
2. fuel consumption rates (gals/hour) and
3. annual usage (hours/year)

The general equation for fuel consumption is:

Fuel Consumption (gals/year) = EPOP x USAGE (hour/year) x FUEL RATE (gals/hour)

where:

EPOP = Equipment population for each category

USAGE = Annual usage for each category (from the guideline document)

FUEL RATE = Fuel consumption rate for each type of equipment (from the reference guideline)

Fuel consumption by each type of farm equipment for Pulaski County is as follows:

GASOLINE POWERED EQUIPMENT

1.	COMBINES	=	60 x 71 x 2.34	=	9,968.4
2.	BALERS	=	67 x 24 x 2.34	=	3,762.7
3.	HARVESTERS	=	0 x 120 x 2.34	=	0.0
4.	TRACTORS	=	458 x 291 x 2.28	=	303,873.8
5.	GENERAL PURPOSE	=	515 x 50 x 3.51	=	90,382.5

DIESEL POWERED EQUIPMENT

1.	COMBINES	=	46 x 71 x 1.5	=	4,899.0
2.	BALERS	=	0 x 24 x 1.5	=	0.0
3.	HARVESTERS	=	10 x 120 x 1.5	=	1,800.0
4.	TRACTORS	=	212 x 490 x 2.98	=	309,562.4
5.	GENERAL PURPOSE	=	514 x 50 x 1.94	=	49,858.0

The general equation for calculating VOC emissions from agricultural equipment is:

$$\text{VOC Emissions (tons/year)} = FC\ (\text{gals}) \div 1{,}000 \times [E_f(\text{lbs}/10^3\ \text{gals}) \times R + E_a(\text{lbs}/10^3\ \text{gals}) \times R_a] \div 2{,}000\ \text{lbs/ton}$$

where:

FC = Fuel consumption by fuel type (gasoline or diesel) for each category

1,000 = Converts fuel consumption data into 1,000 gallon units

E_f = Emission factor for hydrocarbons from AP-42

R_f = Reactivity factor for hydrocarbon emissions (gasoline = 0.86 and diesel = 0.89)[5]

E_a = Emission factor for aldehydes from AP-42

R_a = Reactivity factor for aldehydes (1.0)

VOC emissions (tons/year) from combines are:

VOC (gasoline) =

9,968.4 ÷ 1,000 [(165.63)(0.86) + 4.14] ÷ 2,000 = 0.7

VOC (diesel) =

4,899.0 ÷ 1,000 [(57.1)(0.89) + 10.2] ÷ 2,000 = 0.1

TOTAL 0.8

This procedure is repeated for the other four categories then summed to obtain total farm equipment VOC emissions.

VOC emissions from farm equipment for Pulaski County can be found in Table C-4.

4.2.3.5.2 Construction Equipment

VOC emissions from construction equipment were estimated using fuel usage data. Off-highway gasoline fuel consumption for the year 1975 (24,434,000 gals) was obtained from the Federal Highway Administration's Highway Statistics report.[9] Also, in Highway Statistics, it is estimated that of the total off-highway gasoline used, 1.46% is by construction equipment (356,736 gals). The guideline document[1] indicates that 10.5 times as much diesel fuel is used for construction purposes as gasoline (3,745,288 gals).

These statewide fuel usage figures were then apportioned to Pulaski County on the basis of employment in SIC 16 (heavy construction).[16] VOC emissions for 1975 were calculated by multiplying the gasoline and diesel fuel consumption data by the emission and reactivity factor for construction equipment. These emissions were projected to 1977 VOC emissions on the basis of OBERS[30] earnings projections for the years 1968-1975.

Emission factors from AP-42 that were used for construction equipment are as follows:

Gasoline Powered Equipment -

1. HC = 130.168 lbs/10^3 gals
2. Aldehydes = 4.44 lbs/10^3 gals

Diesel Powered Equipment

1. HC = 34.7 lbs/10^3 gals

2. Aldehydes = 6.78 lbs/10^3 gals

The reactivity factors were assumed to be 0.86 for gasoline and 0.89 for diesel powered equipment, and 1.00 for aldehydes.[5]

The general equation for calculation of VOC emissions (tons/year) from construction equipment is:

$$\text{VOC Emissions (tons/year)} = FC\ (\text{gals}) \div 1{,}000 \times EMP_c \div EMP_s \times [E_a(\text{lbs}/10^3\ \text{gals}) \times R_a + E_f(\text{lbs}/10^3\ \text{gals}) \times R_f] \div 2{,}000\ \text{lbs/ton}$$

where:

FC = Gasoline or diesel fuel consumption for construction equipment in gallons

1,000 = Convert fuel consumption data into 1,000 gallon units

EMP_c = County employment in SIC 16

EMP_s = State employment in SIC 16

E_a = Emission factor for aldehydes from AP-42

R_a = Reactivity factor for aldehydes

E_f = Emission factor for hydrocarbons from AP-42

R_f = Reactivity factor for hydrocarbon emissions

VOC emissions (tons/year) for Pulaski County from construction equipment for 1975 are:

1. Gasoline powered equipment =
   356,736 ÷ 1,000 x 1,750 ÷ 5,011 x
   [130.168 x 0.86 + 4.44] ÷ 2,000 = 7.3

2. Diesel powered equipment =
3,745,288 ÷ 1,000 x 1,750 ÷ 5,011 x
[34.7 x 0.89 + 6.78] ÷ 2,000 = 24.6

TOTAL 31.9

VOC Emissions for 1977 = 31.9 x 1.084 = 34.6

VOC emissions from construction equipment can be found in Table C-4.

4.2.3.5.3 Industrial Equipment

VOC emissions from industrial equipment (forklifts, generators, pumps, and miscellaneous machinery) were based on 1975 statewide fuel consumption data obtained from the Federal Highway Administration's publication, Federal Highway Statistics.[9] Of the total off-highway use for gasoline (24,434,000 gals), 5.65% was used by Industrial equipment (1,380,521 gals). From national fuel estimates for 1973 it is shown that 1.13 times as much diesel fuel is used for industrial purposes as gasoline (1,559,988 gals diesel).

These state totals for gasoline and diesel fuel consumption were distributed to Pulaski County on the basis of employment in SICs 10-14, 20-39, 50 and 51 (found in County Business Patterns).[16] The emission factors from AP-42 used were:

Gasoline Powered Equipment

1. HC = 132.2 lbs/10^3 gals
2. Aldehydes = 4.36 lbs/10^3 gals

Diesel Powered Equipment

1. HC = 37.5 lbs/10^3 gals
2. Aldehydes = 7.04 lbs/10^3 gals

The reactivity factors used for HC emissions were: (1) 0.86 for gasoline fuel and (2) 0.89 for diesel fuel.[5] All aldehyde emissions were assumed to be 100% reactive.

VOC emissions for 1975 were calculated by multiplying the gasoline and diesel fuel consumption data by the emission and reactivity factors for

industrial equipment. These emissions were projected to 1977 VOC emissions on the basis of OBERS[30] earnings projections for the years 1968 - 1975.

The general equation for calculation of VOC emissions (tons/year) from industrial equipment is:

$$\text{VOC Emissions (tons/year)} = FC(\text{gals}) \times EMP_c \div EMP_s[E_f(\text{lbs}/10^3\ \text{gals}) \times R_f + E_a\ (\text{lbs}/10^3\ \text{gals}) \times R_a] \div 2{,}000\ \text{lbs/ton}$$

where:

FC = Fuel consumption in 1,000 gal units for either gasoline or diesel fuel

EMP_c = County employment in SICs 10-14, 20-39, 50 and 51

EMP_s = State employment in SICs 10-14, 20-39, 50 and 51

E_f = Emission factor for HC emissions from either gasoline or diesel powered equipment

R_f = Reactivity factor for HC emissions

E_a = Emission factor aldehyde emissions

R_a = Reactivity factor for aldehyde emissions

VOC emissions (tons/year) from industrial equipment for Pulaski County are:

1. Gasoline =
   1,380.521 x 34,821 ÷ 201,149 [132.2 x 0.86 + 4.36 x 1.00] ÷ 2,000 = 14.1
2. Diesel =
   1,559.988 x 34,821 ÷ 201,149 [37.5 x 0.89 + 7.04 x 1.00] ÷ 2,000 = 5.5

1975 TOTAL 19.6

VOC Emissions for 1977 = 19.6 x 1.085 = 21.3

VOC emissions from industrial equipment for Pulaski County can be found in Table C-4.

4.2.3.5.4 Lawn and Garden Equipment

Lawn and garden equipment VOC emissions were based on the number of owner occupied houses in Pulaski County; this assumes that each housing unit has one lawnmower. Owner occupied housing data were taken from the Census of Housing.[31]

Assuming that all the engines used in lawn and garden equipment are four stroke, the emission factors from AP-42 are:

1. Hydrocarbon exhaust and evaporative combined = 3.76 lb/unit year
2. Aldehydes = 0.07 lb/unit year

Hydrocarbon emissions were assumed to be 95% (from Mobile Source Emission Factors[22] for four-stroke motorcycle engines) and aldehydes 100% reactive, respectively.

The general equation to calculate VOC emissions from lawn and garden equipment is:

$$\text{VOC (tons/year)} = H \times [E_f(\text{lbs}/10^3 \text{ gals}) \times R_f + E_a(\text{lbs}/10^3 \text{ gals}) \times R_a] \div 2{,}000 \text{ lbs/ton}$$

where:

H = Owner occupied housing units

E_f = Hydrocarbon emission factor from AP-42

R_f = Reactivity factor for hydrocarbon emissions

E_a = Aldehyde emission factor from AP-42

R_a = Reactivity factor for aldehyde emissions

VOC emissions (tons/year) from lawn and garden equipment for Pulaski County are:

$$\text{VOC Emissions} = 52{,}049 \times [3.76 \times 0.95 + 0.07 \times 1.00] \div 2{,}000 = 94.8$$

VOC emissions (tons/year) from lawn and garden equipment can be found in Table C-4.

SECTION 4

REFERENCES

1. Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, Volume 1, EPA-450/2-77-028, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December, 1977.

2. "Recommended Policy on Control of Volatile Organic Compounds, "Federal Register, Vol. 42, No. 131, July 8, 1977. pp. 35314-35316.

3. Compilation of Air Pollutant Emission Factors, Third Edition, Publication AP-42, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August, 1977. (Also includes supplements 1 through 7).

4. "Mobile Source Emissions Model," U. S. Environmental Protection Agency, Office of Transportation and Land Use Policy, January, 1978.

5. Reactive Hydrocarbon Control Costs for Los Angeles, Final Report to U. S. Environmental Protection Agency, by TRW Environmental Engineering Division, under Contract No. 68-02-2445, June, 1977.

6. Analysis of Data for Hydrocarbon Sources in Non-Attainment Areas in Louisiana, Volume 1, Final Report to U. S. Environmental Protection Agency, by TRW Environmental Engineering Division, under Contract No. 68-01-3152, November 12, 1976.

7. "Local Climatological Data," Monthly Summary, National Oceanic and Atmospheric Administration, National Climatic Center, 1977.

8. "Road and Street Mileages," Arkansas State Highway and Transportation Department, Division of Planning and Research, January, 1978.

9. Highway Statistics, Section 1 and 4, FHWA-HP-HS-75-01R, U. S. Department of Transportation, Federal Highway Administration, Washington, D. C., 1975.

10. Aviation Forecast- Fiscal Years 1978-1979, Department of Transportation, FAA, September, 1977.

11. Census of U. S. Civil Aircraft--Calendar Year 1975, Department of Transportation, FAA, 1975.

12. "Waterways and Harbors, Gulf Coast, Mississippi River System and Antilles," Waterborne Commerce of the United States, Part 2, U. S. Department of the Army, Corps of Engineers, 1976.

13. Study to Support New Source Performance Standards for the Dry Cleaning Industry, Final Report to U. S. Environmental Protection Agency, by TRW Environmental Engineering Division, under Contract No. 68-02-1412, May 7, 1976.

14. "United States Production and Sales, 1975," Synthetic Organic Chemicals, USITC Publication 804, United States International Trade Commission, 1977.

15. Methodologies for Countywide Estimation of Coal, Gas, and Organic Solvent Consumption, EPA-450/3-75-086, U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, December, 1975.

16. County Business Patterns 1975, Arkansas, CPD-75-5, U. S. Department of Commerce, Bureau of the Census, September, 1977.

17. 1972 Census of Selected Services, Volume 1, Summary and Subject Statistics, U. S. Department of Commerce, Bureau of the Census, July, 1976.

18. "Crude Petroleum, Petroleum Products, and Natural Gas Liquids: 1975," Mineral Industry Surveys, U. S. Department of the Interior, Bureau of Mines, February 24, 1977.

19. "Estimates of the Population of U. S.: July 1, 1977 (Revised) and 1976 Provisional)," Current Population Reports, Series P-26, No. 76-4, U. S. Department of Commerce, Bureau of the Census, August, 1977.

20. "State and County Economic Data for Arkansas," University of Arkansas, College of Business Administration, Industrial Research and Extension Center, December, 1977.

21. Arkansas Counties Social and Economic Profile, Arkansas State Highway and Transportation Department, Planning and Research Division, Finance and Economics Section, October, 1977.

22. Mobile Source Emission Factors, Environmental Protection Agency, Office of Transportation and Land Use Policy, January, 1978.

23. National Vehicle Registration Service, R. L. Polk and Company, March, 1978.

24. "1974 Emission Inventory From Aircraft," Arkansas Department of Pollution Control and Ecology, 1974.

25. "Military Air Traffic Report," 1976, 1975, 1974, 1973, U. S. Department of Transportation, Federal Aviation Administration, Annual.

26. "Sales of Fuel Oil and Kerosine in 1976," Energy Data Reports, Department of Energy, Energy Information Administration, 1976.

27. Class I and II Railroad Annual Reports, 1977, 1976, 1975, and 1974, U. S. Interstate Commerce Commission, Rail Section.

28. "Transportation Map of Arkansas," U. S. Department of the Interior, Geological Survey, 1975.

29. Census of Agriculture, County Data, U. S. Department of Commerce, Bureau of the Census, 1974.

30. 1972 OBERS Projections, Volume 5, Standard Metropolitan Statistical Areas, U. S. Department of Commerce, Bureau of Economic Research, and U. S. Department of Agriculture, Economic Research Service, April, 1974.

31. "1970 Census of Population and Housing," Little Rock--North Little Rock, Arkansas, Census Tracts, U. S. Department of Commerce, Bureau of the Census, 1972.

APPENDIX A

STATIONARY POINT SOURCE EMISSIONS

TABLE A-1. POINT SOURCE VOC EMISSIONS FOR PULASKI COUNTY[a]

SOURCE	1977 EMISSIONS (TONS/YEAR)
AFCO STEEL, INC.	12.3
AGL CORP.	1.3
A. O. SMITH-INLAND, INC.	335.6
ARMSTRONG RUBBER CO.	62.8
BUCKEYE CELLULOSE CORP.	151.2
DIMAC MANUFACTURING CO., INC.	1.6
ECONO AUTO PAINTING	7.4
EXXON, INC.	313.5
FRANKLIN ELECTRIC CO.	99.7
GULF OIL, INC.	151.9
HERMAN BINZ AND SONS	2.5
INTERNATIONAL GRAPHICS	34.2
LA GLORIA OIL AND GAS CO.	363.6
LITTLE ROCK FURNITURE MFG. CO.	144.0
MASONITE CORP.	22.4
MOBIL OIL CORP.	31.3
MURPHY OIL CORP.	42.2
ROL-LIFT CORP.	11.6
SOUTHERN SCREW MACHINE PRODUCTS	4.1
STAUFFER CHEMICAL CO.	1.9

[a] ONLY THOSE SOURCES REPORTING EMISSIONS GREATER THAN ONE TON/YEAR ARE LISTED.

TABLE A-1. (CONCLUDED)

SOURCE	1977 EMISSIONS (TONS/YEAR)
STEBBINS AND ROBERTS, INC.	7.0
SUPERWOOD CORP.	1.2
TELETYPE CORP.	1.2
TEXACO, INC.	47.2
TRIANGLE ENGINEERING	6.6
W. R. GRACE AND CO.	43.6
WACO MANUFACTURING CO.	1.6
TOTAL	1,940.4

(a) ONLY THOSE SOURCES REPORTING EMISSIONS GREATER THAN ONE TON/YEAR ARE LISTED.

TABLE A-2. POINT SOURCE VOC EMISSIONS FROM JEFFERSON COUNTY[a]

SOURCE	1977 EMISSIONS (TONS/YEAR)
CENTRAL MOLONEY, INC.	120.0
FLORIDA DRUM DELTA CO., INC.	31.3
HOOVER UNIVERSAL, INC.	17.8
ILLINOIS TOOL WORKS, INC.	22.1
PINE BLUFF ARSENAL	35.9
W AND A MANUFACTURING CO.	21.6
WAFFORD MANUFACTURING CO.	8.0
TOTAL	256.7

[a] JEFFERSON IS THE ONLY CONTY ADJACENT TO PULASKI COUNTY THAT HAS EMISSION SOURCES GREATER THAN ONE TON/YEAR.

APPENDIX B

STATIONARY AREA SOURCE EMISSIONS

TABLE B-1. PULASKI COUNTY SURFACE COATING EMISSIONS

CATEGORY	VOC EMISSIONS (TONS/YEARS)
INDUSTRIAL SURFACE COATING	
LARGE APPLICANCES	5.7
MAGNETIC WIRE	182.4
TRANSPORTATION EQUIPMENT	41.2
CANS	14.1
PAPER	358.0
FABRIC	163.7
WOOD FURNITURE	44.1
FLAT WOOD PRODUCTS	51.1
OTHER METAL PRODUCTS	200.0
OTHERS	352.8
NON-INDUSTRIAL SURFACE COATING	
ARCHITECTURAL COATINGS	113.0
AUTO REFINISHING	90.7
TOTAL	1,616.8

APPENDIX C

MOBILE SOURCE EMISSIONS

TABLE C-1. 1977 VOC EMISSIONS FROM MOTOR VEHICLES

AVERAGE SPEED (MPH)	EMISSION FACTOR (GRAMS/MILE)	VMT	VOC EMISSIONS (TONS/YEAR)
25.0	9.38	167	0.63
30.0	8.59	1,690,122	5,841.3
40.0	7.61	564,700	1,729.0
45.0	7.36	1,380,418	4,087.8
53.5	7.18	45,373	131.1
55.8	7.09	1,200,971	3,425.9
57.8	7.00	246,041	693.0
60.3	6.83	272,423	748.6
		TOTAL	16,657.3

TABLE C-2. 1977 VOC EMISSIONS FROM AIRCRAFT

AIRCRAFT TYPE	1977 LTO CYCLES	VOC EMISSIONS (TONS/YEAR)
MEDIUM RANGE JET	9,262	52.8
AIR CARRIER TURBOPROP	2,997	8.1
BUSINESS JET	1,260	4.2
GENERAL AVIATION	73,894	16.6
MILITARY	70,674	667.1
HELICOPTER	673	0.2
TOTAL	158,760	749.0

TABLE C-3. 1977 VOC EMISSIONS FROM VESSELS AND PLEASURE CRAFT

CATEGORY		VOC EMISSIONS (TONS/YEAR)
VESSELS		
INPORT		0.0
UNDERWAY		5.3
	TOTAL	5.3
PLEASURE CRAFT		
INBOARD (GASOLINE)		3.3
INBOARD (DIESEL)		5.7
OUTBOARD (GASOLINE)		992.6
	TOTAL	1,001.6
	GRAND TOTAL	1,006.9

TABLE C-4. 1977 VOC EMISSIONS FROM OTHER OFF-HIGHWAY FUEL USE

CATEGORY	VOC EMISSIONS (TONS/YEAR)
FARM EQUIPMENT	
COMBINES	0.8
BALERS	0.3
HARVESTERS	0.1
TRACTORS	35.4
GENERAL PURPOSE	8.2
TOTAL	44.8
CONSTRUCTION EQUIPMENT	34.6
INDUSTRIAL EQUIPMENT	21.3
LAWN AND GARDEN EQUIPMENT	94.8
GRAND TOTAL	195.5